Optical Disks vs. Micrographics

Synopsis

Editor's Note

Professional information managers frequently debate whether optical disks or micrographics offer better document storage and retrieval characteristics. Those favoring optical disk technology contend that it offers newer and functionally better characteristics than micrographics.

Optimistic market forecasts seem to support these managers' views. Yet most records managers, information specialists, and industry analysts continue to see advantages in micrographics technology.

Highlights

William Saffady's *Optical Disks vs. Micrographics* has become a standard reference for comparing optical disk and micrographics technologies. Its analysis can help professionals responsible for choosing document storage and retrieval systems assess their options.

This report summarizes Mr. Saffady's findings. It compares systems based on these two technologies according to their input methods, storage media, and retrieval characteristics.

Analysis

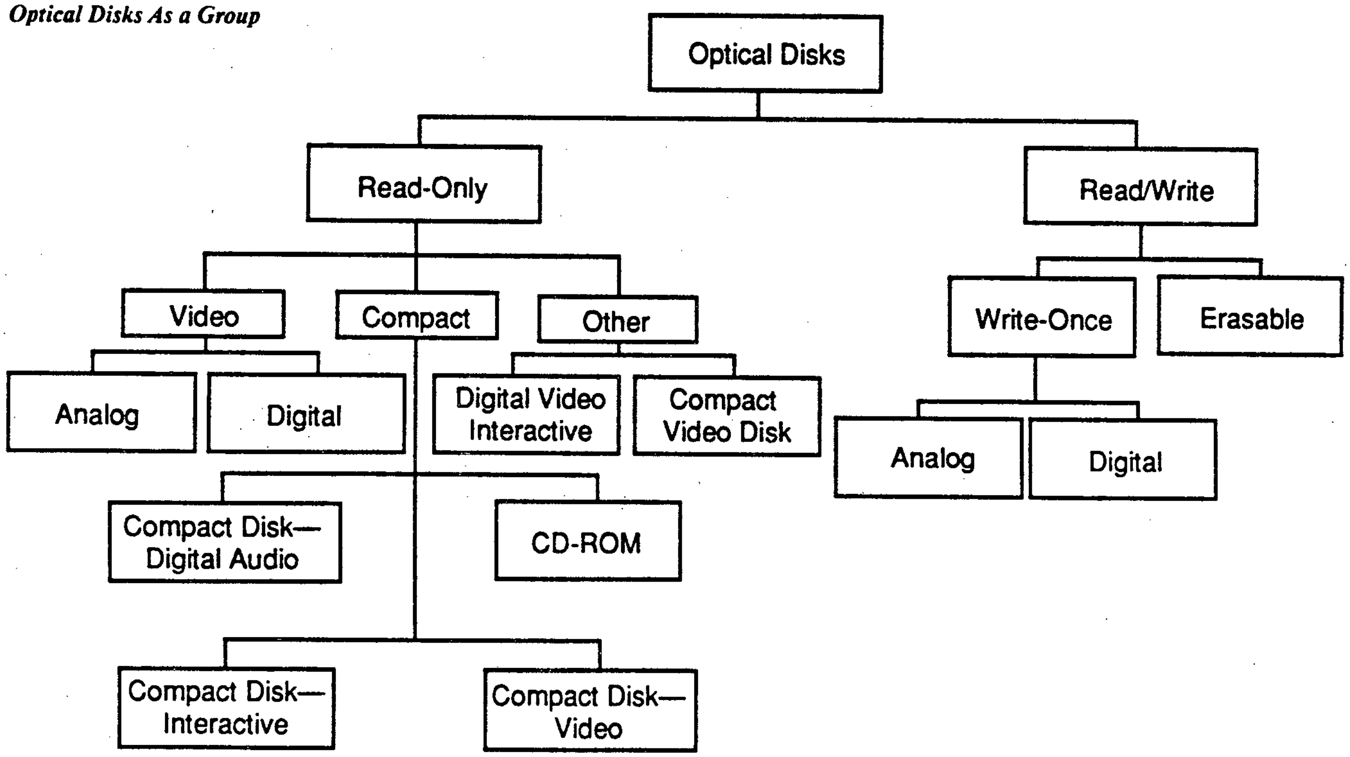
Optical disks and micrographics are alternative document storage and retrieval technologies, but not all optical disks compete with all micrographics devices. Within these two broad categories of devices, only optical filing and computer assisted retrieval (CAR) systems compete directly. This report's cost-benefit comparisons focus on these two types of storage and retrieval systems.

Optical disks encompass a wide range of devices (See Figure 1). The optical disk market includes both read-only and read/write disks. Read-only disks employ either analog or digital technologies. Users can read them but cannot record on them. Read/write disks, including analog write-once, digital write-once, and digital erasable disks, allow users to record and then retrieve information. As the names imply, *write-once* disks are immutable once recorded; *erasable* disks allow users to remove and replace information.

CAR represents state-of-the-art micrographics storage and retrieval technology for active records management applications. A hybrid technology, CAR combines computer hardware, computer software, and micrographics equipment to index and retrieve document images recorded on microfilm, microfiche, or other microforms. To the space saving and archival benefits of micrographics, CAR adds the computer's capability to manipulate rapidly index data stored on magnetic disks.

Optical filing systems use read/write disks, and they compete directly with CAR for active information storage and retrieval. They employ computer hardware and software to store digitized document images on optical disks for subsequent retrieval. Optical filing systems are not appropriate for compact, long-term storage of inactive records.

Figure 1.
Optical Disks As a Group



Optical disks comprise a wide range of products.

Both alternatives are available in preconfigured or custom-developed systems. End users find it easier, however, to custom-build CAR systems than optical filing systems.

Building the computer portion of a tailored CAR system requires a central processor (mainframe, minicomputer or microcomputer), one or more indexing and retrieval workstations with video displays and keyboards, and sufficient disk storage for software and index data. The micrographics components include cameras, other microfilm production equipment, and retrieval and display devices. These components are readily available, and records managers, systems analysts, and other end users can apply them to a CAR system successfully. On the other hand, many potential CAR users do not have the time, experience, or financial resources for this difficult, time-consuming, and expensive proposition. Preconfigured, turnkey systems usually meet their needs for straightforward applications requiring rapid implementation.

The components for an optical filing system are also separately available, but the systems engineering requirements for integrating them lie beyond most end users' abilities. Customizing an optical filing system requires an experienced systems integrator, who tailors the system for a specific application. The alternative, a preconfigured, turnkey system, is often sufficient for straightforward records management applications.

Input Methods

The primary input device for an optical filing system is a scanner. Its CAR counterpart is a camera. Both devices convert paper records to compact images for storage and subsequent retrieval.

A scanner is a computer peripheral device that converts paper documents to digitally-coded, machine-readable images that can be transmitted to host computers and recorded onto optical disks. The scanner attaches to a host computer; the optical recording medium operates on a computer's external disk drive. The external disk drive usually operates online to the same host computer that serves the scanner, though some vendors offer separate scanning stations that capture document images for later transfer to the optical filing system.

A microfilm camera is a self-contained, reprographic device that produces microfilm, microfiche, or other microforms. It includes a light source and a lens system to record document images on a photosensitive medium, which itself is loaded directly into the camera. The camera does not produce an exact document image. Integral microprocessors control most newer microfilm cameras, but attachment to an external computer is not required for operation.

For both scanners and microfilm cameras, desktop models are the most popular. Floor-standing scanners are available, however, and systems integrators include them in customized applications.

Some scanners resemble commonly used planetary-type microfilm cameras in that they employ an overhead scanning unit mounted on a vertical column above a copyboard on which documents appear face-up. Most scanners, however, are flatbed devices that more closely resemble facsimile machines. While some scanners are manually fed, most, like rotary and automatic-feed planetary microfilm cameras, use automatic feeders.

Scanners and rotary microfilm cameras are generally limited to single-page input, while planetary microfilm cameras accommodate bound volumes. All handle U.S. letter-size and international A4-size pages, and most planetary cameras and scanners designed for business records take several other sizes of input documents as well. Specialized scanners and planetary cameras exist for large documents, such as engineering drawings, maps, charts, newspapers, and x-rays. Rotary cameras are restricted to 11 inches in width but offer the advantage of accommodating documents of any length, including continuous forms.

Resolution

Resolution, an indicator of image quality, has different meanings when applied to the two technologies. It measures the ability of a document scanner or microfilm camera to render detail visible. In scanning, or document digitization, resolution denotes the specific pattern and number of picture elements (pixels) a scanner samples, usually expressed as dots per inch or millimeter, or even the older lines-per-inch measure associated with facsimile transmission systems. Scanning resolution—the potential for detail in the digitized image—

varies directly with the density of the pixels. Microfilm resolution, on the other hand, indicates the number of separate lines per millimeter discernable in a processed microimage.

Resolution tests exist for both technologies, but manufacturers' claims are usually accepted for scanners without on-site verification. Post-processing inspection for microfilm applications, however, is routine.

Two hundred pixels per inch generally is the minimum resolution required for scanners, and 110 to 120 lines per millimeter with 24x reduction exceeds the requirements of most records management applications. Image evaluation is subjective, however, and the appropriate resolution depends upon the nature of the original material, the recording requirements, and the user preference.

Microfilm cameras can accommodate textual and pictorial documents with reasonable resolution, and color microfilm is available. Most scanners are suitable only for textual documents. Some customized systems handle pictorial documents, but they contain more bits per pixel, and so use up more storage space.

Conversion Speed

Document conversion speed influences labor requirements and costs. *Rated operating speed* measures the time required to convert one paper document to digital form or to a microform image. The interval begins when the document is positioned for scanning or filming, and it ends when the document can be removed from the scanner or camera.

Scanners offer a wide range of speeds. Most minicomputer-based, turnkey optical filing system scanners can digitize a letter-size page in three to six seconds, but lower-priced, microcomputer-based configurations support scanners that require as long as 20 seconds to digitize a letter-size page. Because page sizes differ, it is easier to rate scanners by inches or centimeters scanned per second. Speeds vary from about 3.76 inches per second for those that digitize a letter-size page in three seconds, to 0.55 ips for those that digitize a letter-size page in 20 seconds.

Rotary cameras microfilm documents as they pass through a transport mechanism, and most can film as fast as an operator can insert the originals. They can record up to 2,000 or 3,000 letter-size pages per hour, reaching 6.1 to 9.1 inches per second, but few operators can sustain these insertion rates. Users can more realistically expect to process 1,000 letter-size pages per hour. Automatic-feed planetary cameras provide comparable results. These rates are competitive with the best scanner speeds, and are twice as fast as the slowest scanners.

Actual throughput must account for work steps not included in rated operating speed. *Work throughput analysis* calculates the time required to complete a given quantity of work in a specific situation by considering such work routines as document preparation, indexing, media processing, and image inspection.

Hypothetical calculations show that comparative performance varies according to the type of camera used. A rotary microfilm camera operating at 1,000 pages per hour requires about the same input time as a comparably priced scanner. A planetary microfilm camera operating at only 500 pages per hour, however, requires significantly more input time than an optical filing system equipped with a comparably priced scanner.

Storage Media

Optical disks are general computer storage media that record machine-readable, digital signals generated by scanners, keyboards, or other devices. These signals can encode both document images and character-coded data. Micrographic systems, even though they can be combined with computers for various information management applications, are designed specifically for document reproduction and storage. In terms of their storage media, CAR and optical filing systems differ in their recording technologies, page capacities, duplication technologies, physical stability, degree of standardization, and legality.

Recording Technologies

CAR and optical disk filing systems differ considerably in their recording technologies. They differ in technological maturity, function, and range of applications.

Stages of Development

Microfilm systems have been used in business applications for over 50 years. A large body of literature exists to explain them, and their recording technologies are well understood. Recent developments have refined existing processes and products rather than introduce innovations.

In contrast, read/write optical disk systems are at a developmental stage comparable to that of micrographics in the 1950s and 1960s, when severe competition existed among processes and products. Write-once disks, have proved appropriate for records management applications where file integrity is essential and erasure is either seldom required or undesirable. Erasable disks may not be suitable for reliable information storage and retrieval systems for several years. They do, however, offer the capability—not generally supported by micrographics systems—to alter document records.

Page Capacities

Although both media can store many documents in relatively small amounts of space, their relative page capacities differ. Several variables influence page capacity. CAR document storage capacities depend on the type of microform used, the sizes of the documents to be recorded, the image format and reduction ratio, and the number of filed targets or blank frames between documents. Camera-specific characteristics such as the distance between successive document images and leader and trailer film requirements also influence storage capacity.

An optical disk's storage capacity varies with the characteristics of the stored documents. Most systems apply computer-based compression algorithms to reduce the amount of disk space required. Documents with much contiguous light and dark space have greater compression potential than densely printed documents with more frequent light-to-dark transitions.

In addition, the higher the resolution in optical disk systems, the greater the disk space they require for document storage. Microform capacity, in contrast, is never affected by resolution. At 200 pixels, for example, it takes six ANSI Type-6 Fiche to accommodate the number of pages on one 115M-byte optical disk. At 400 pixels, it takes only one ANSI Type-6 Fiche to equal the capacity of one 115M-byte optical disk. Clearly, capacity comparisons are closely tied to the resolution requirements and document characteristics of the specific application.

As in the case of input speed, however, the total analysis of storage requirements is complex. *Areal density* goes beyond page capacity to compare the amount of information that can be recorded per square inch of media surface. This is a useful calculation because the various media differ in size. Expressed in bytes per square inch, areal density is obtained through a simple formula:

$$D = A/B$$

where

D = the areal density of a single recording surface;
A = the recording surface's area in square inches; and
B = the recording surface's storage capacity in bytes.

For micrographic media, the storage capacity must be translated into its equivalent in bytes, a unit of measure peculiar to digitally recorded information.

Although areal density is a far more useful figure than page capacity, it is expressed in bytes per square inch of recording surface and thus does not provide a practical measure of physical space needed to house information stored on the various media. The *storage space requirement*, based upon the number of letter-size pages per cubic foot of storage space, answers this need. Table 1 shows the comparative storage efficiency of the media, the optical disk unit capacities assume a scanning resolution of 200 pixels per horizontal and vertical inch with a compression factor of 10 for letter-size pages. In addition, the table makes assumptions about the types of boxed storage that contain the media.

As Table 1 shows, considerable differences exist in the number of pages that various devices store per cubic foot. As a group, 5.25-inch optical disks with capacities in excess of 500 MB offer the most efficient use of physical storage space, accommodating over one million pages per cubic foot.

These variations, however, may seem negligible considering that in recording information from paper documents, all microforms and optical disks provide huge reductions in required physical storage space. Space savings range from 93.6435 to 99.9330 percent. Prices vary from a low of $.0045 per page for 100-foot, 16mm microfilm to a high of $.19 per page for 5.25-inch optical disk cartridges with B4-size documents scanned at a resolution of 400 pixels per inch (the cost is $.049 per page at 200 pixels per inch). In addition, the media costs associated with document scanning or source document microfilming bear consideration.

Table 1. Comparative Storage Efficiency (in Pages per Cubic Foot) for Various Media

Storage Medium	Container Type	Container Dimensions*	Required Space (Cubic Feet)	Units Per Container	Pages Per Unit	Pages Per Cubic Foot**
Paper	Carton	10x12x15	1.042	1,200	1	1,152
1 GB WORM Disk	Jukebox	31x75x80	107.639	95	21,390	18,878
2 GB WORM Disk	Jukebox	31x75x80	107.639	95	42,781	37,758
1 GB WORM Disk	Cartridge	13x13x1	0.098	1	21,290	218,710
115 MB WORM Disk	Cartridge	6x5.5x.5	0.010	1	2,460	257,629
100-ft Microfilm	Carton	8x4x24	0.444	48	2,500	270,000
1.3 GB WORM Disk	Cartridge	13x13x1	0.098	1	27,807	284,322
1.8 GB WORM Disk	Cartridge	13x13x1	0.098	1	38,503	393,687
2 GB WORM Disk	Cartridge	13x13x1	0.098	1	42,781	437,429
200 MB WORM Disk	Cartridge	6x5.5x.5	0.010	1	4,278	448,023
750 MB WORM Disk	Cartridge	9x8x.75	0.031	1	16,043	513,376
230 MB WORM Disk	Cartridge	6x5.5x.5	0.010	1	4,920	515,258
3.4 GB WORM Disk	Cartridge	15x15x1	0.130	1	72,727	558,543
2.6 GB WORM Disk	Cartridge	13x13x1	0.098	1	55,615	558,655
215-ft Microfilm	Carton	8x4x24	0.444	48	5,375	580,500
300 MB WORM Disk	Cartridge	6x5.5x.5	0.010	1	6,417	672,035
Type-1 Fiche	Carton	6x4x24	0.333	2,400	98	705,600
3.6 GB WORM Disk	Cartridge	13x13x1	0.098	1	77,005	787,365
400 MB WORM Disk	Cartridge	6x5.5x.5	0.010	1	8,556	896,047
1.5 GB WORM Disk	Cartridge	9x8x.75	0.031	1	32,086	1,026,752
6.8 GB WORM Disk	Cartridge	15x15x1	0.130	1	145,455	1,117,094
500 MB WORM Disk	Cartridge	6x5.5x.5	0.010	1	10,965	1,148,335
600 MB WORM Disk	Cartridge	6x5.5x.5	0.010	1	12,834	1,344,070
800 MB WORM Disk	Cartridge	6x5.5x.5	0.010	1	17,112	1,792,093

**In inches*
***Letter-size pages*

Duplication Technologies

Microform and optical disk duplication technologies differ significantly. In micrographics, copy films and special contact printing equipment produce one or more duplicates of master microforms. Fully automatic, high-volume devices produce a known number of copies at a rate of 1,000 to 2,000 per hour, in advance and at a scheduled time. Low-volume, desktop, convenience models create single microform copies as needed by manual operation. The high volume models cost from $10,000 to more than $50,000, depending upon speed and options; low-volume equipment ranges from $2,000 to $6,000.

Optical disk duplication involves transferring the disk's contents electronically through a host computer's memory to another optical disk, a task easily accomplished in a dual-drive equipment configuration. The media duplicating speed depends upon the disk drive's transfer rates, ranging from 440 kilobits to 3.8 megabits per second. This translates to approximately 70 to 600 pages per minute. A typical production-type duplicator operating at 1,000 microfiche per hour, on the other hand, handles about 1,630 to 7,100 pages per minute, depending upon the format. Convenience duplicator speed ranges from 98 to 840 pages per minute.

The media costs also differ considerably. Microfilm costs approximately $.0024 to $.0036 per page and optical disks rarely lower than $.01 per page. The cost of an additional write-once optical disk drive ranges from $2,500 to $15,000.

On the other hand, optical disk duplication creates no resolution loss. Microforms can suffer a 10 percent degradation of image detail with each generation.

Media Stability

The *stability* of a storage medium indicates its resistance to deterioration caused by internal decomposition and external environmental factors. Stability can be divided into shelf stability and storage stability.

Shelf stability or shelf life is the period of time during which an optical disk or microform remains useful for recording. In microforms, shelf stability is generally from six months to one year from the date of purchase. Updatable microfiche, however, can be exposed more than once to add new images to unused areas, and its shelf stability lasts one to three years for adding new material. Write-once optical disk media can also be exposed repeatedly to add information to unused segments. Its claimed useful shelf file is five years, after which time its low error rate deteriorates.

Storage or *playback stability* is the period during which recorded information can be retrieved reliably. Years of study have allowed a thorough understanding of microform storage stability. Microforms that conform to the appropriate published standards for storage conditions can be depended upon for long-term (100-year) and even archival (permanent) storage and retrieval.

Optical disk retrieval periods are not yet so well understood. Manufacturers sometimes call them archival, meaning that they allow data transfer from magnetic disk to magnetic tape or other offline storage. From the point of view of the records manager, however, optical disks are not archival. Manufacturers claim a minimum playback life of only 10 to 30 years without significant deterioration in error rates. Even these claims are sometimes questioned, based as they are upon accelerated aging tests and not actual, long-term experience. Of course, in such a new and changeable field, new generations of improved products will likely have been introduced before the useful lives of current disks end.

Standardization

The relative ages of the two technologies affect their standardization. Microforms generally comply with numerous published industry standards, but optical disk equipment and media have seen little formal standardization. There exists, therefore, little media compatibility among the optical disk systems of different manufacturers, even where they use the same disk sizes and recording technologies. On the other hand, optical filing systems store document images in a digitized format suitable for electronic transfer to other systems and media, regardless of physical compatibility.

Legality

From a legal standpoint, the two media are similar, though micrographics is more clearly recognized in law. Two statutes—developed in 1949 and 1953—specifically address the status of microform copies in United States jurisdictions where they have been adopted. The statutes, for the most part, admit microform copies in evidence as substitutes for original records. In some cases, specific state statutes may restrict admissibility.

In 1987, the Texas State legislature passed the first law regarding the use of optical storage technology. It accorded digital information recorded on optical storage media the same legal status as information recorded on microfilm. The Uniform Photographic Copies of Business and Public Records in Evidence Act and the Uniform Rules of Evidence Act seem applicable to digitized document images recorded on optical disks. The medium's limited stability has no impact on legal status, since the statutes do not require archivally stable copies.

Retrieval Characteristics

Optical filing systems and CAR systems use conceptually similar retrieval methods. Both technologies rely on computer-based indexes and both record images in random sequence, determined by the order of their arrival at input workstations. Beyond these basic similarities, their indexing procedures, retrieval workstations, and retrieval procedures differ.

Indexing Procedures

Both types of systems rely on computer-based indexes that link subject terms or other index values

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to specific document images. The indexes contain pointers that indicate the images' physical locations. The index, typically, is a structured, machine-readable data file created and maintained by data management software and containing one record for each document. Index records consist of user-defined categories, or fields, that contain character-coded data values. The indexing categories and values assigned to document images recorded on optical disks and on microfilm can be identical. In either case, magnetic disks house the index records for fast access and convenient editing.

CAR systems generally exploit one of three indexing procedures. The first procedure involves stamping documents with identifying microform and frame numbers before or during filing. Documents are then routed to online indexing terminals for key-entering of their microform addresses and relevant index terms.

In the second procedure, the user key-enters the microform addresses and index terms from microfilm or microfiche images displayed on a reader or reader/printer. In this method, the microfilm is already processed and indexing can coincide with image inspection. As an added option, the user can configure the reader/printer with an electronic interface for online connection to an indexing terminal, to advance film from image to image and transmit frame numbers to the terminal automatically, eliminating key-entering.

A third procedure uses special workstations that combine indexing terminals and overhead planetary cameras. This method automatically inserts the document's frame number into the appropriate index field. With the index record completed and verified, the operator presses a key to activate the camera's shutter, which films the document and increments the frame number simultaneously.

Optical filing systems require less complicated procedures. Generally, the operator inspects and indexes digitized images of scanned documents at a video terminal immediately after scanning. If the image quality is unacceptable, the operator can re-scan the document. Completely transparent to the operator, the system automatically transfers the indexed, digitized images to computer-assigned disk locations.

Retrieval Workstations

CAR and optical filing systems also use different types of retrieval workstations. CAR combines a conventional, alphanumeric video display terminal with a microform retrieval unit. All CAR systems require separate display devices for index data and document images. Optical filing system workstations, however, employ single, high-resolution bit-mapped video terminals that display both character-coded index data and digitized document images. They require considerably more internal memory than CAR alphanumeric video terminals.

Most optical filing installations include a laser printer for hard copy output, serving as the counterpart of the microform reader/printer. With the proper parameters established, laser printing requires no operator intervention, and some optical filing systems offer background printing capabilities for document output even while index searches continue. The laser printers operate at nearly twice the speed of xerographic reader/printers, which only reproduce microimages rather than generating the hard copy output of laser printers.

Retrieval Procedures

With both CAR and optical filing systems, retrieval procedures begin with the operator locating the necessary microform(s) or optical disk cartridge(s) through an index search, then retrieving and mounting them. In CAR installations, the operator manually enters the frame number of the document image within a mounted cartridge at the reader/printer's keypad. The reader/printer advances the film to the indicated image. With an online reader/printer interface, operators do not need to enter frame numbers manually, and most newer reader/printers have small internal memories that store multiple frame locations downloaded from a host computer.

Optical filing systems never require manual entry of frame locations. With the optical disk cartridge mounted, the system automatically retrieves and displays the appropriate image. Optical filing systems offer faster access to specified document images—about three seconds once the disk is located and mounted—because of their disks' direct access capabilities.

Roll microfilms, being serially organized, require that the retrieval unit physically pass through

Table 2. Comparison of Typical Retrieval Times CAR vs. Optical Filing Systems

	Seconds Required to Complete	
Work Step	**CAR**	**Optical Filing**
Index search	30	30
Locate Medium	20	20
Access Document Image	7	3
Print Document Image	10	6
Rewind Medium	5	—
Remove/Replace Medium	20	20
Total Transaction Time	92	79

all preceding document images. Their average retrieval time is 5 seconds per image for 100-foot length film and 10 seconds per image for 215-foot film. While microfiche systems offer direct access, their limited storage capacity incurs increased media handling time. Automated microfiche retrieval units locate and display frames from microfiche stored in cartridge-like containers. They offer access times from 3 to 5 seconds per page for a mounted fiche and 5 to 10 seconds per page for an unmounted fiche.

Table 2 compares typical retrieval times from index search through removal or replacement of the medium. The optical filing system reduces retrieval time by about 10 percent, representing 13 seconds per retrieval; 275 retrievals save approximately one hour. The time saved allows more work to be accomplished at a single workstation, reducing hardware requirements and the associated costs for high volume retrieval applications.

The large capacity of some optical disks increases the probability that the next desired image will be on the already mounted disk. Thus, they save disk removal and replacement time. Optical filing systems can have multiple disk drives, further increasing the probability that a required image will be located on a mounted disk.

Multiple drives are usually located in jukebox units. These devices feature one or more optical disk drives, a collection of optical disk cartridges arranged in stacks or bins, an integral microprocessor to receive instructions from an external computer, and a robotic mechanism that responds to the instructions by extracting and mounting the optical disks. A typical jukebox reduces document retrieval time by 39 percent compared with a manual disk retrieval CAR system, and 28 percent compared with a manual disk retrieval optical filing system.

Each transaction may save only seconds, but the accumulated savings increase significantly as the volume of retrieval transactions grows. In addition, a jukebox unit can service multiple workstations through a local area network (LAN). Using a LAN eliminates media duplication for scattered offices. Jukeboxes can cost $100,000, but in high volume and multiple workstation settings, the savings in time and duplication can offset the cost in a reasonable period of time.

Comparing and Combining

The cost factors presented above offer a financial framework for specific comparisons of CAR and optical filing system features. Generally, CAR systems require slightly less input labor and offer much lower storage media costs than optical filing systems. Optical filing systems, however, can provide significant time and labor savings in document retrieval.

Broad cost comparisons might be misleading because document storage and retrieval applications vary so widely. The potential buyer should analyze its own specific situations to determine the relative costs associated with its operations.

Instead of focusing on the choice between optical disk and micrographic technologies, many analysts recommend that buyers recognize their conceptual similarities and potential for complementary use. The two may coexist, at least in the near future. Optical disks may initially be limited to those few users with a very high volume of document storage and retrieval.

Some analysts believe that future document storage and retrieval systems will combine the two technologies. Hybrid systems can exploit CAR's and optical filing systems' conceptual similarities, particularly their use of computer indexes. Other possibilities include combining optical disk jukeboxes with microform retrievers for completely automated media handling.

Hybrids can offer more effective approaches to a broader range of information management tasks than either technology alone. Optical disk components would give hybrids very high media capacity, immediately available digitized images, convenient, single-terminal access to index data and document images, fast display and printing for active documents, and transfer of digitized images to remote workstations or facsimile transceivers. Micrographics components would provide low media cost, easy and inexpensive media duplication for vital records protection or distribution to multiple access points, media stability, and firm legal definition. Hybrids can also be effective for implementing optical filing technology where large numbers of documents are already on microfilm, eliminating the time-consuming scanning now necessary for conversion.

These considerations lead some analysts to view CAR as an effective interim technology. They see it as viable until optical filing system prices decline and experience with optical disk technology increases.

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